Advanced Distributed Generation at DoD Facilities

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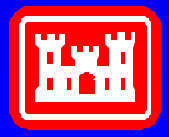
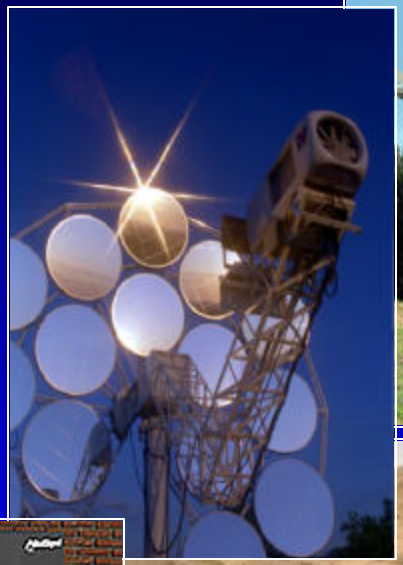


Advanced Distributed Generation



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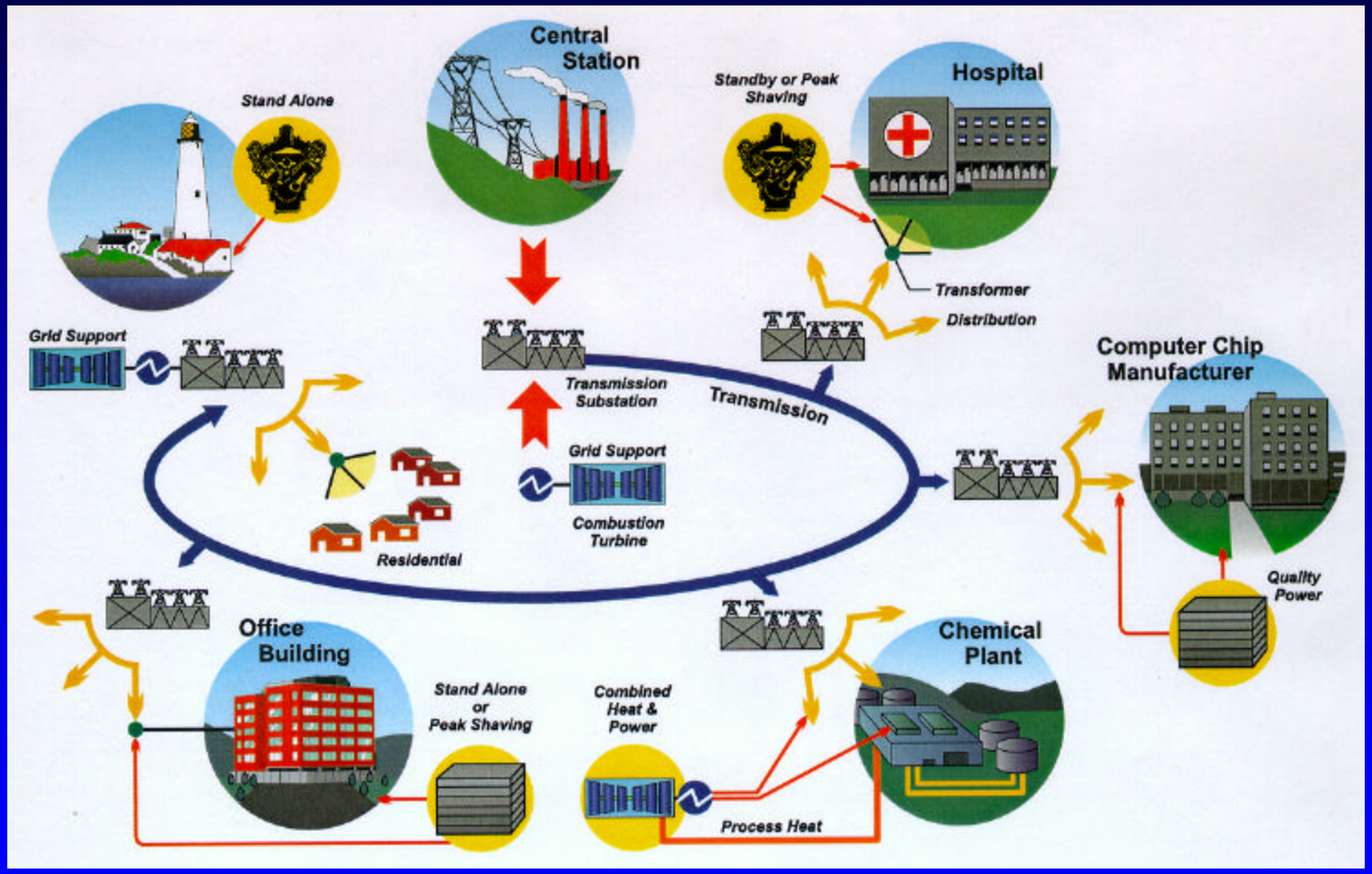
What is Distributed Generation?



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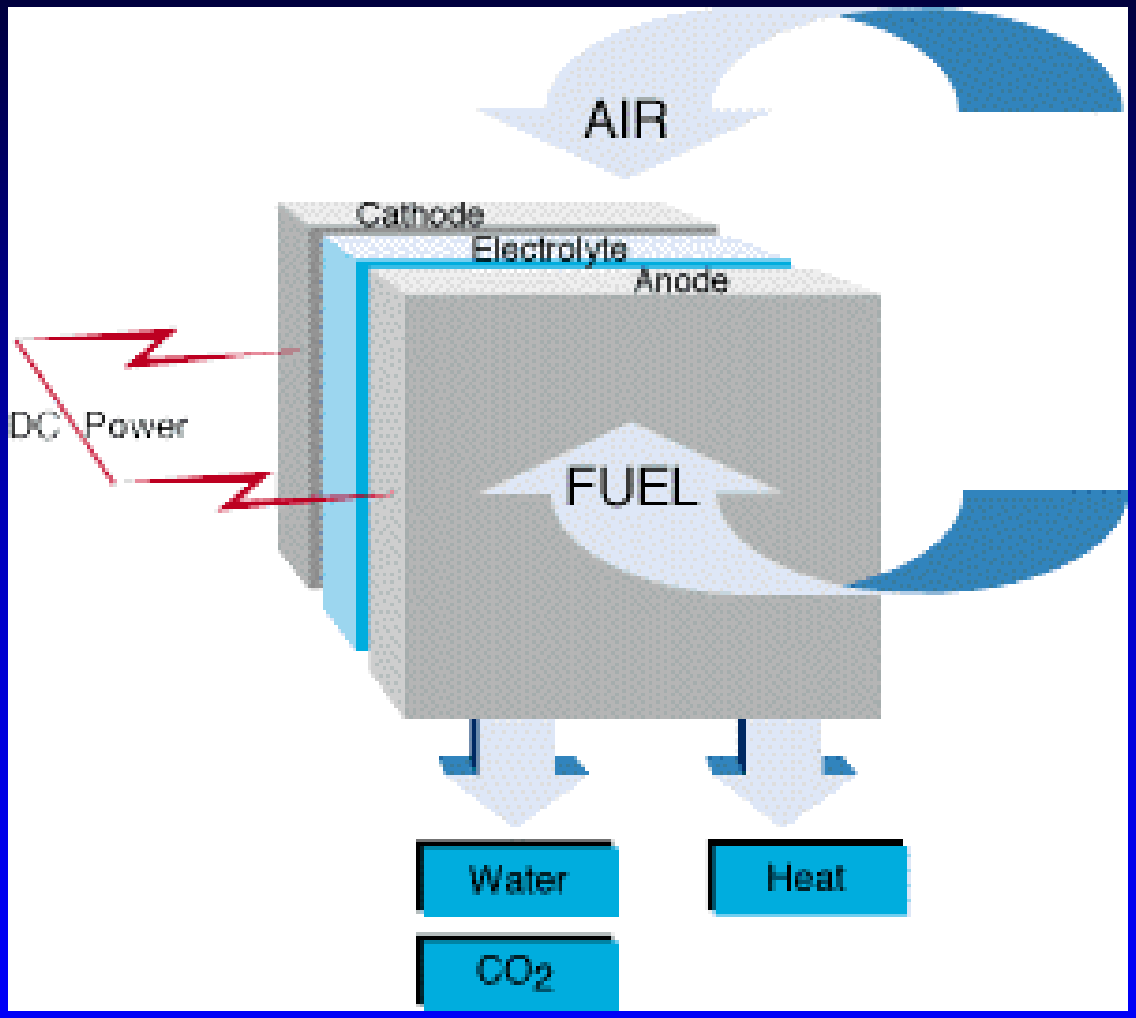
Advanced DG Technologies

- Fuel Cells
- Micro-Turbines
- Advanced Reciprocating Engines
- Wind Power
- Photovoltaic Power
- Stirling Engines

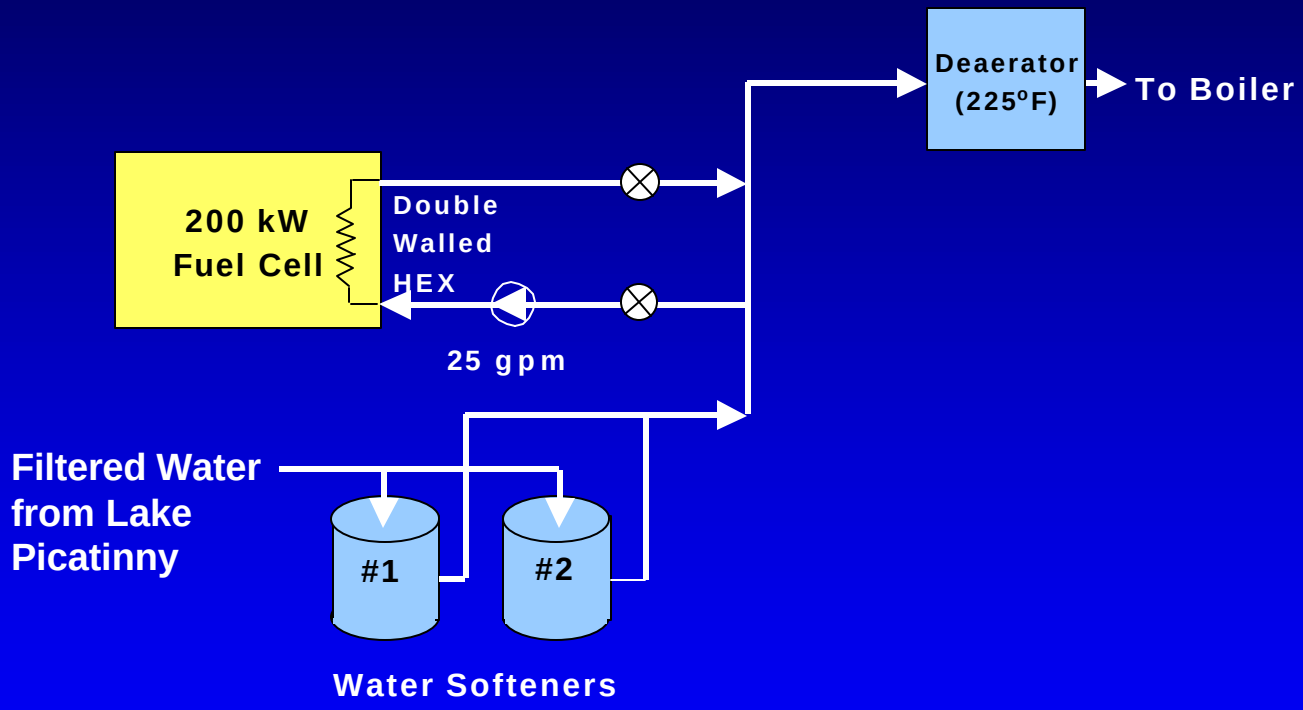
Fuel Cells



Fort Richardson, Anchorage AK

Picatinny Arsenal, Dover NJ

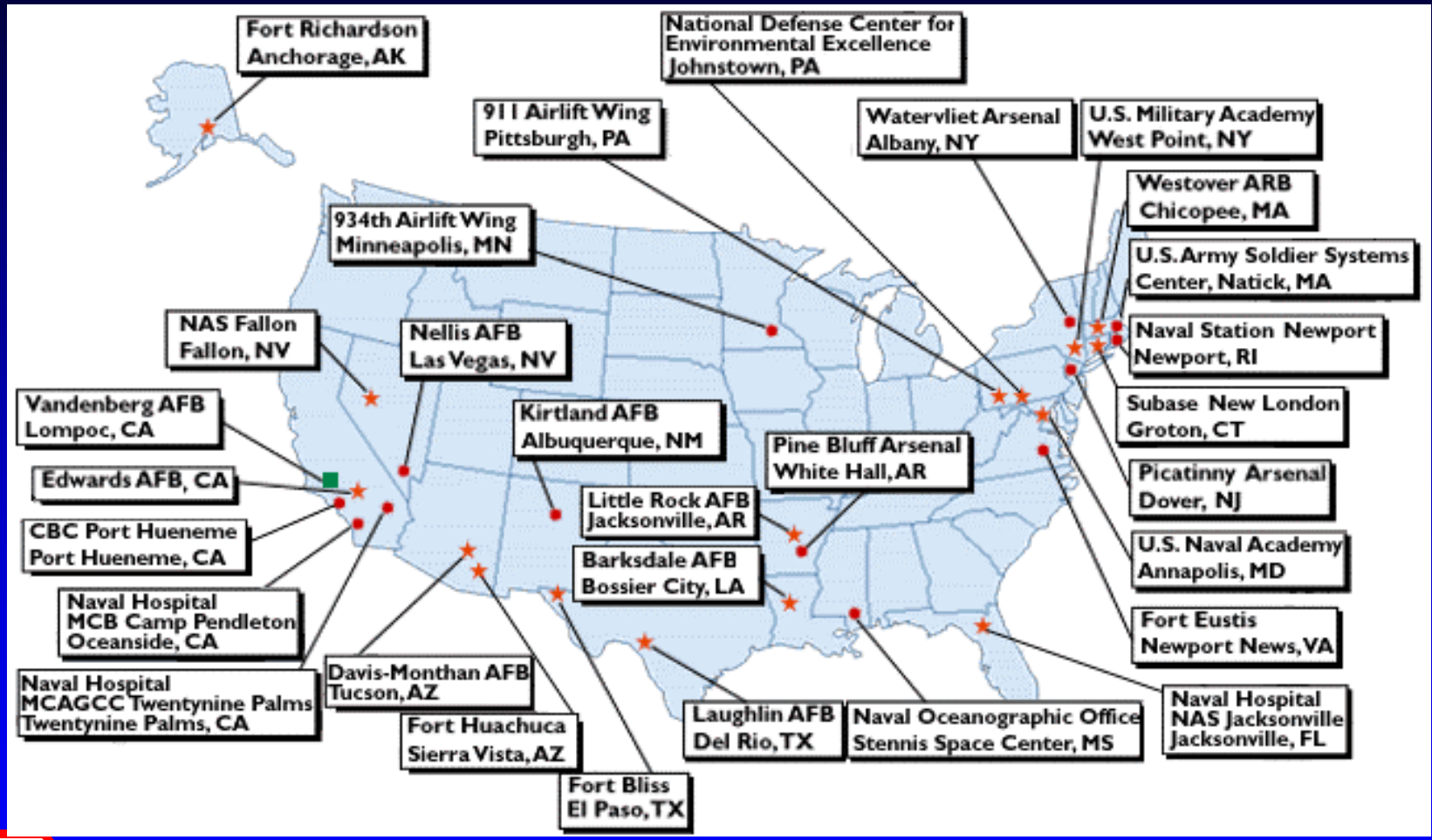
Example Thermal Interface



Fuel Cells

- Just one commercial product available today but many are due in the next few years
- Quiet, no emissions, high efficiency
- Very reliable, high-quality power - currently expensive, $4000/kW, but could fall as low as $100/kW in mass production
- Many sizes, from laptop power supply to megawatt scale

Fuel Cells – DoD Fleet



Fuel Cells

Further advancements include...

- Development of molten carbonate, solid oxide, PEM, and alkaline technologies
- Development of vehicle applications will impact mass production, which will lower costs further

Micro-Turbines

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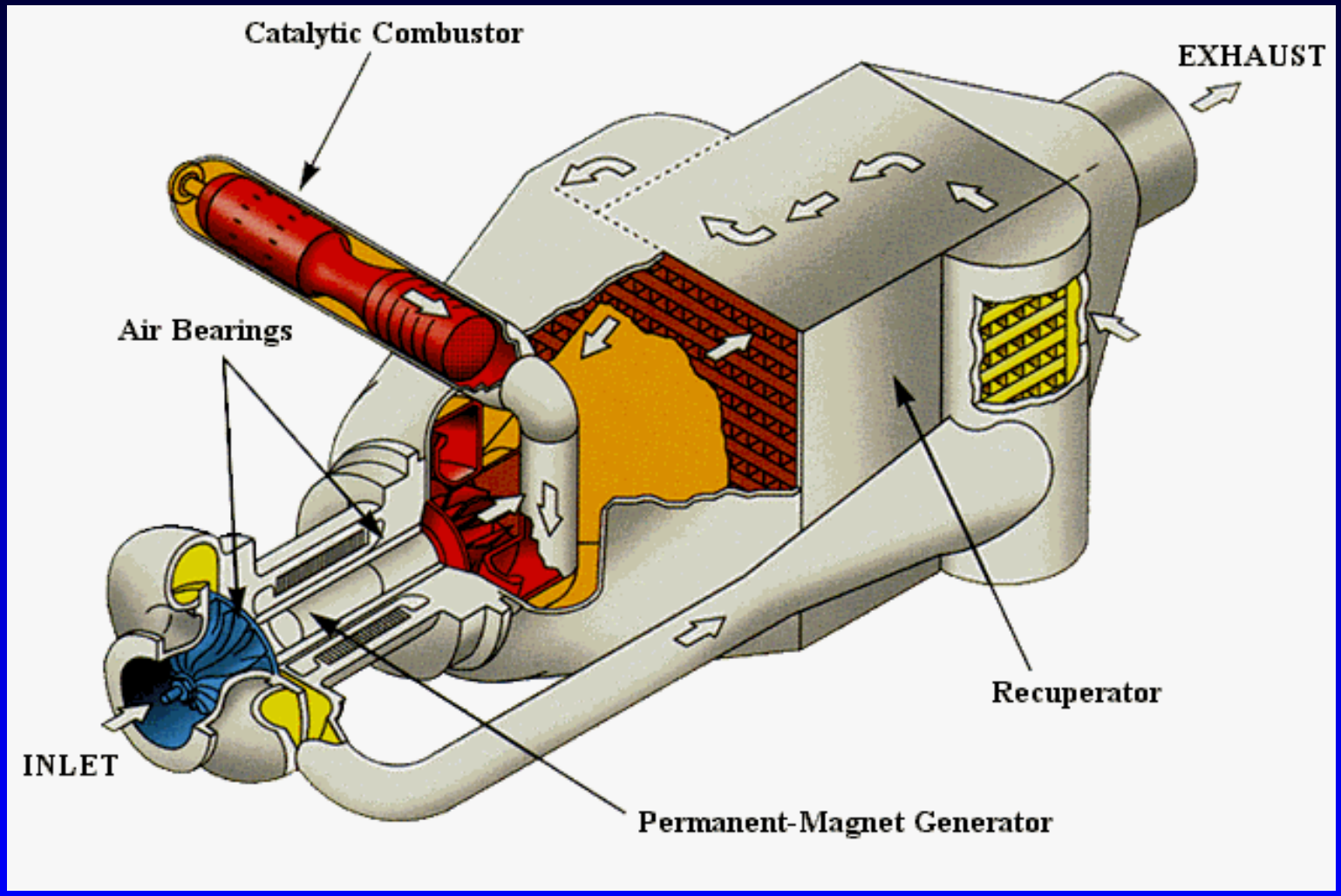
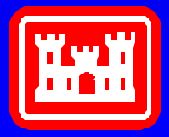
Micro-Turbines



Micro-Turbines

- Miniature versions of combustion turbines widely used by utilities and co-gen developers
- Vehicle as well as facility applications
- Higher efficiency and lower emissions than reciprocating engines
- Multiple fuels



Micro-Turbines

- Range from 30-kW units to a few hundred kilowatts
- One moving part - reduced maintenance
- First commercial models available in 1999
- Market entry prices approximately $600/kW, projected below $400/kW
- Product infrastructure support unproven

Micro-Turbines

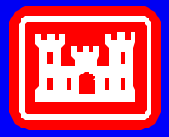
Further advancements include...

- **Establish support infrastructure**
- **Investigate and demonstrate units that are currently being commercialized**

Advanced Reciprocating Engines

Advanced Reciprocating Engines

- Established technology with global infrastructure support
- Used in nearly all natural gas powered generators less than a megawatt
- Mass produced by many companies
- New packaged and small commercial co-gen systems



Advanced Reciprocating Engines

- Many sizes, from 5 kW to megawatts
- Drawbacks - emissions, noise, and relatively high maintenance
- $500-$1500/kW
- Less efficient than micro-turbines

Advanced Reciprocating Engines

Further advancements include...

- Monitor performance in comparison to conventional diesel generators
- Feasibility of converting existing diesel gen-sets to ARE

DG Applications

- Stand-alone
- Emergency back-up
- Combined heat and power
- Peak shaving
- Grid support

Customer Benefits

- Power quality, security, and reliability
- Flexible power for a wide range of loads
- Environmentally sustainable
- Reduces energy cost volatility in a deregulated market